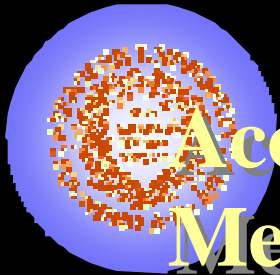


January 19, 2005



Acoustic Monitor for Solids and Gas Measurements at Low Volume Fractions

Motivations for Research

- Applicability to measure solid concentrations in slurries in the presence of small amounts of gas bubbles
- Applicability to measure gas concentrations in gas-liquid systems

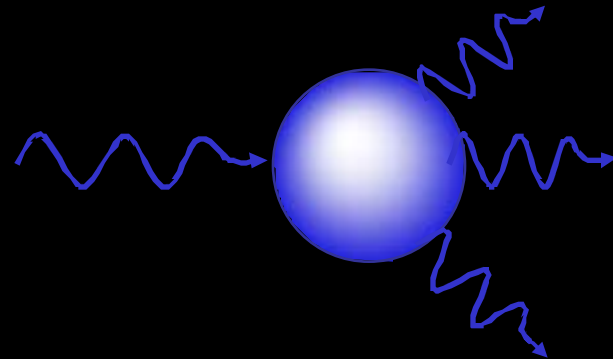
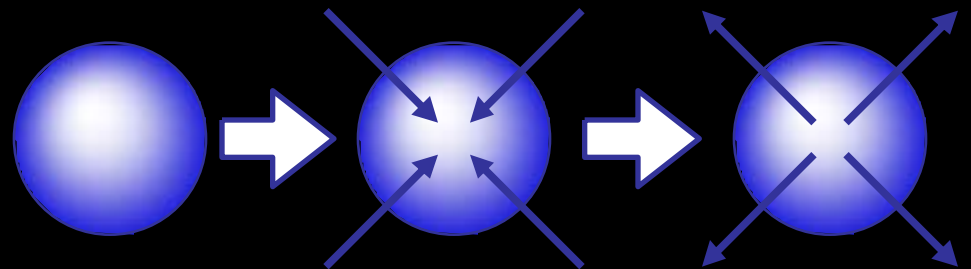
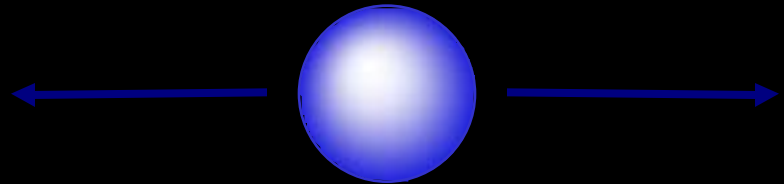
Outline

loop

- **Current Work**

- Develop a radiation-resistant housing with acceptable acoustic properties
- Demonstrate application to SRS surrogate slurries over broad range of concentrations
- ✓ Demonstrate an application of this monitor on surrogate slurries at SRNL, Aiken, SC
- ✓ Develop an acoustic probe for placement and measurements in mixing vessels
- ✓ Expand application to measure low gas concentrations in gas-liquid systems

Attenuation Mechanisms



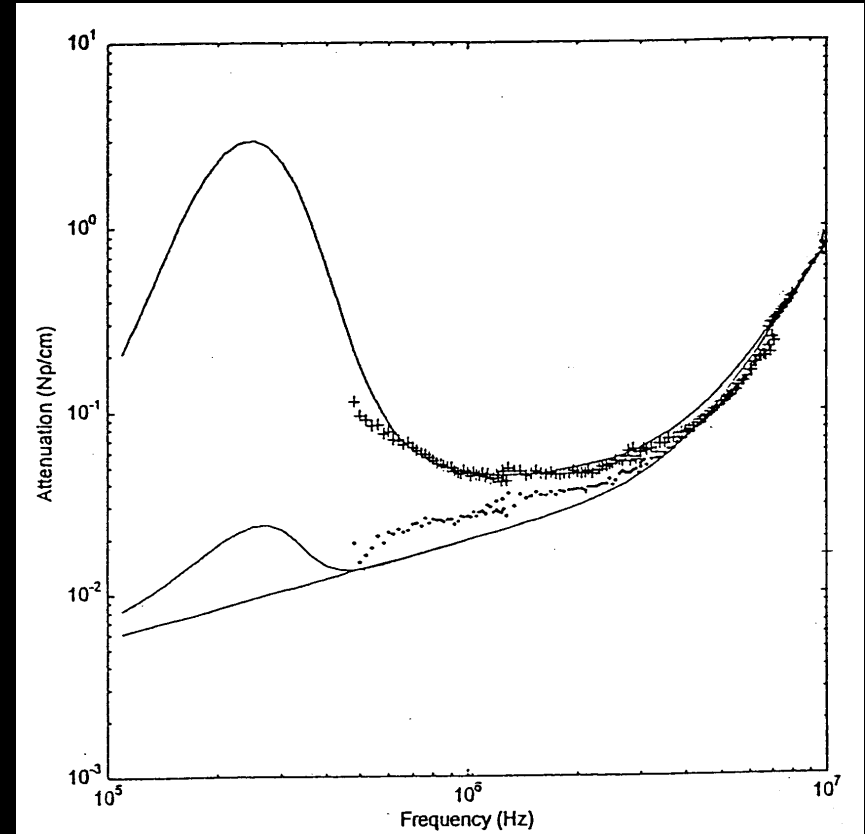
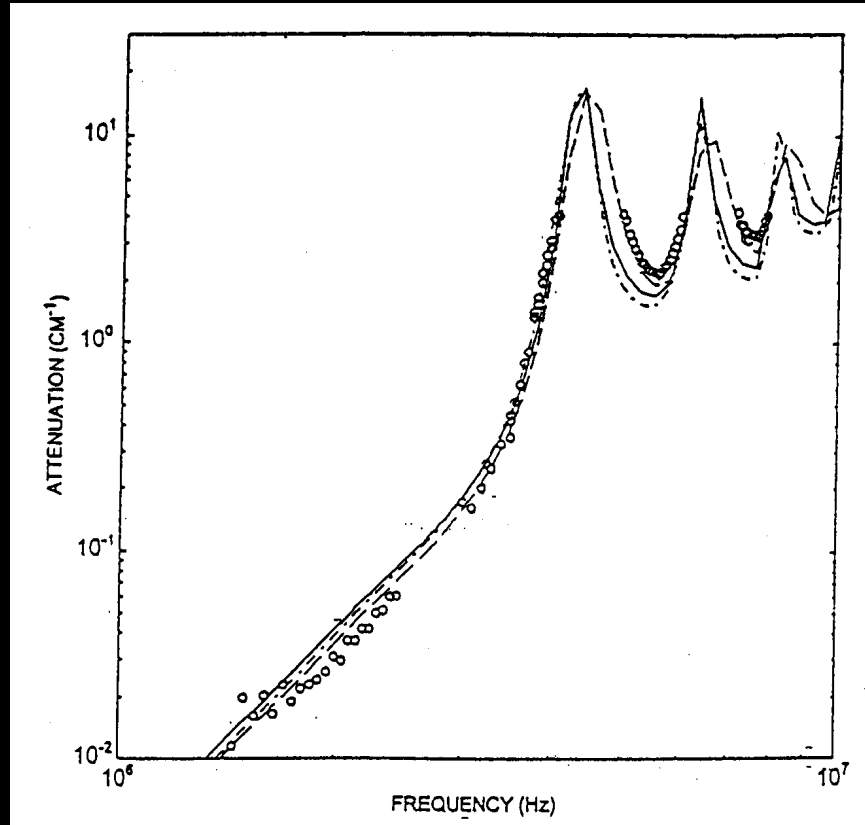
Theory

determined by solving the governing equations for the particle-shell combination so they are consistent with the averaged equations for the suspension

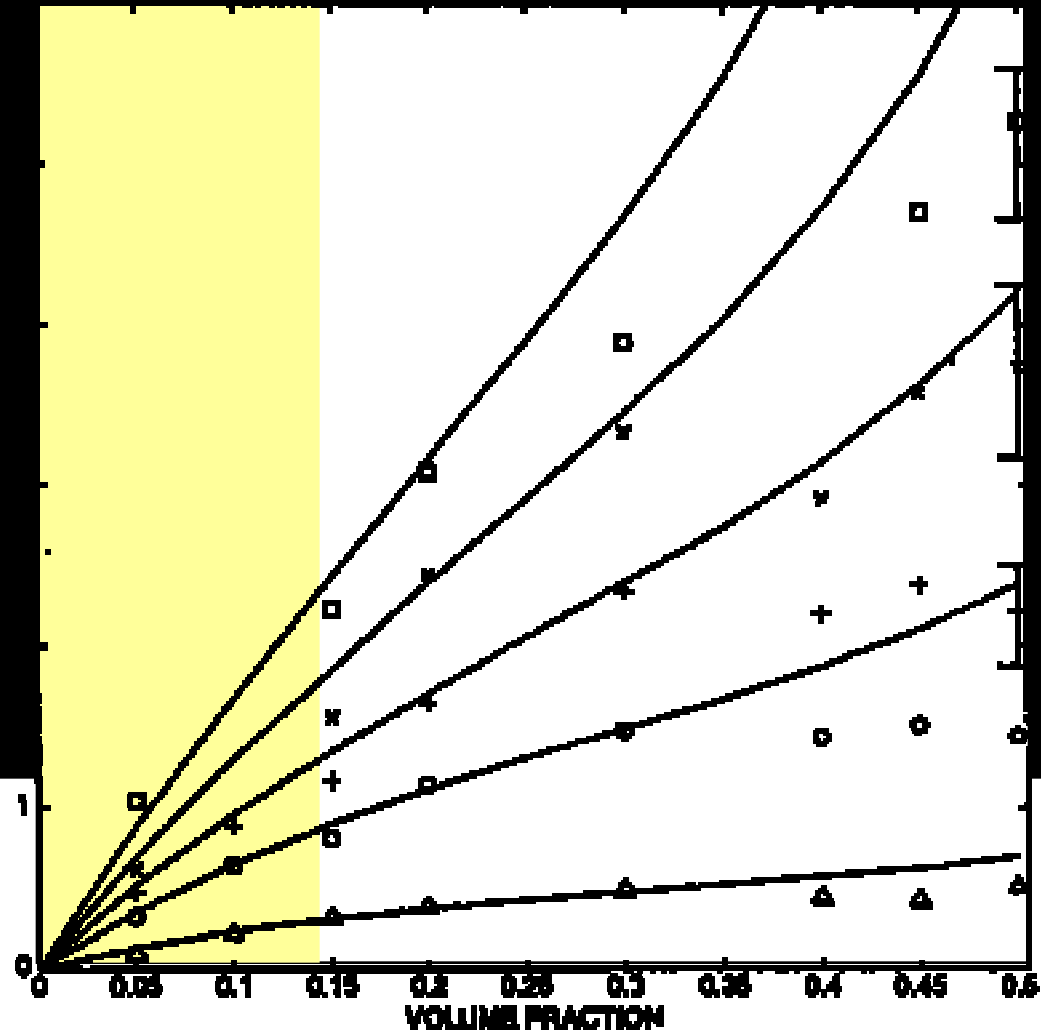
Spelt et al., “Determination of Particle Size Distribution from Acoustic Wave Propagation”, Physics of Fluids, Vol. 11 ms, 1065—1080.

Spelt et al., “Attenuation of Sound in Concentrated Suspensions: Theory and Experiments”, J. of Fluid Mech. Vol. 430, 51—86, (2001)

Theory and Experiment: Comparison



Theory and Experiment: Comparison



Low weight
fractions –
subject of the
current work

Approach to the High-Speed Concentration Measurements

Test Cell Operation

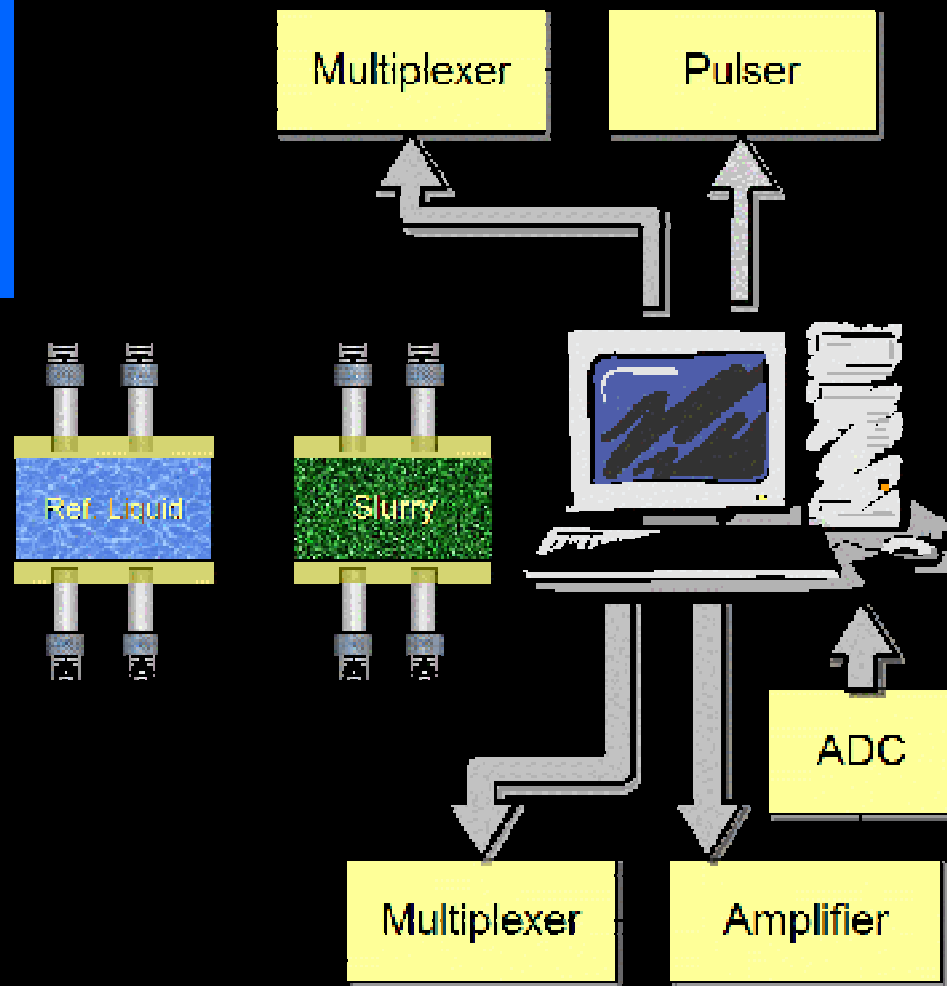
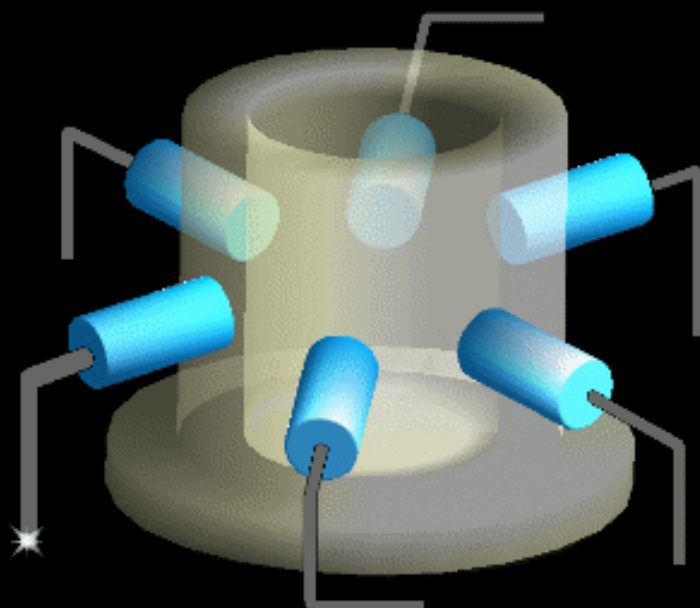
New Test Cell Housing Properties:

Material: Ultem 1000 (Polyetherimide)

Radioactive stability: 95% residual strength after 400 MRad (Co) exposure

Chemical Stability: High

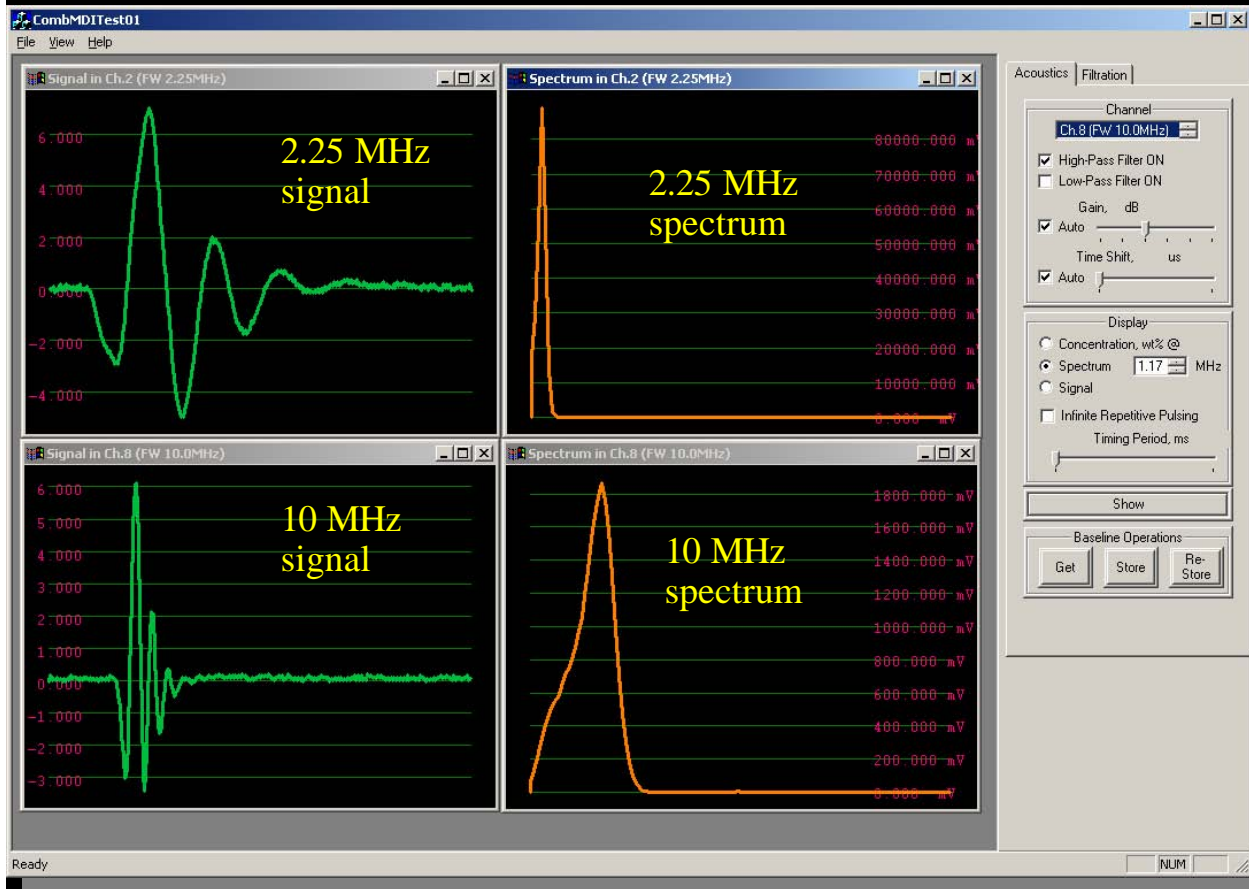
Ultimate Strength: 24500 psi tensile



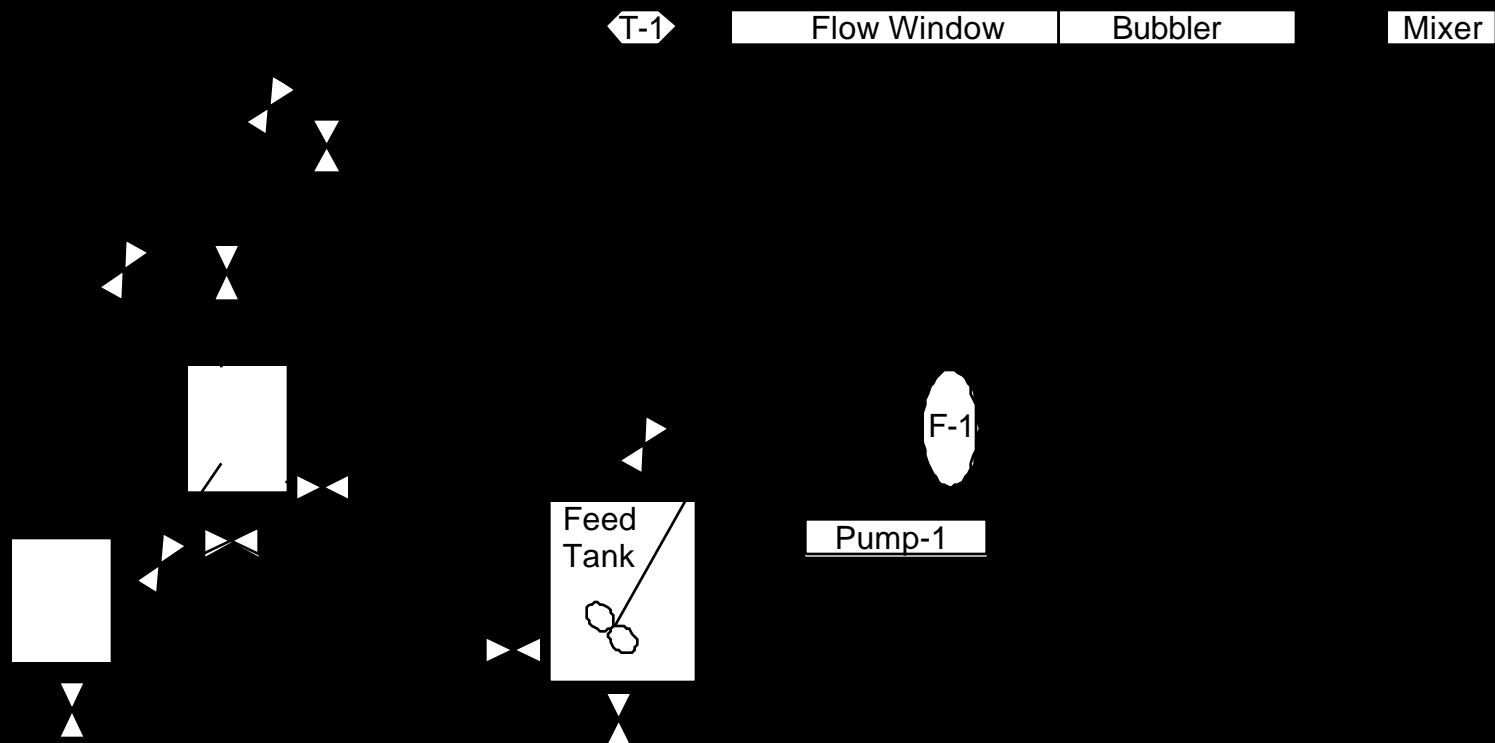
Signal Acquisition and Processing

Data acquisition software –
Acoustic Control Panel

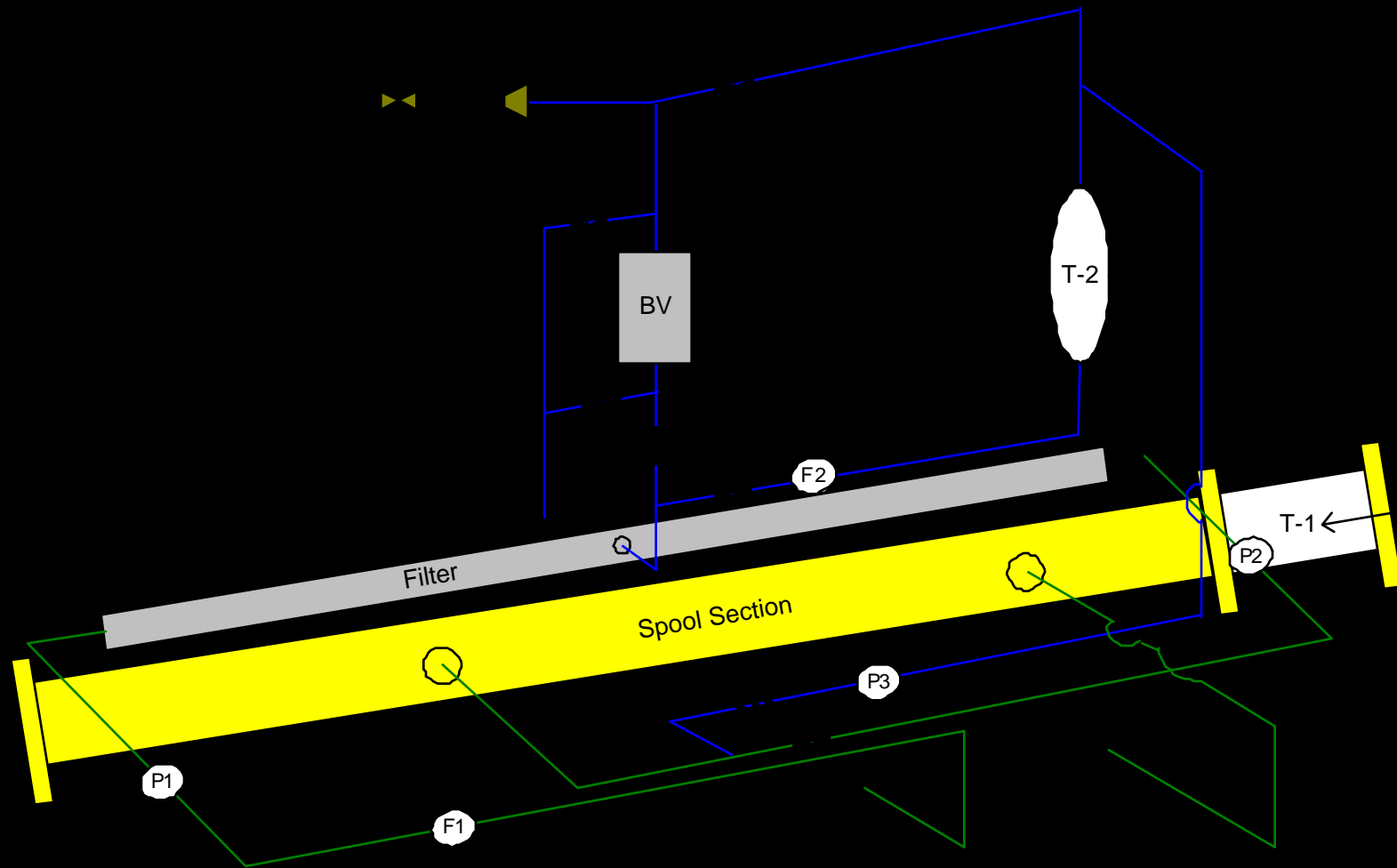
Attenuation of the acoustic
signal in the slurry is
determined as



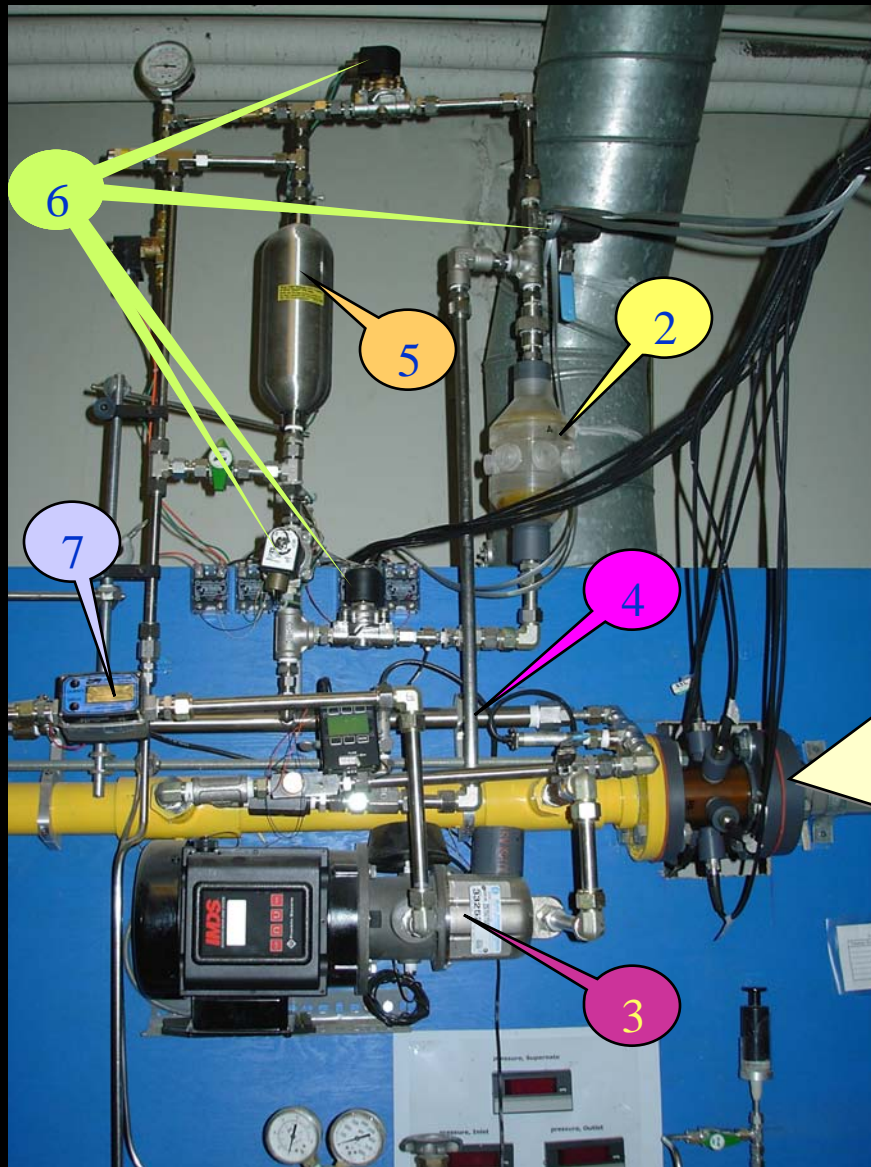
Experimental Apparatus: Flow Loop Design



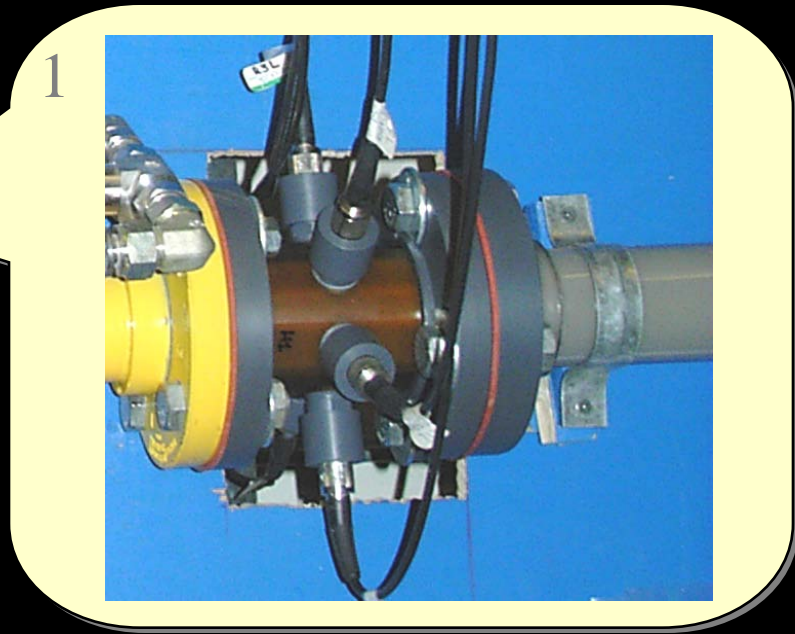
Experimental Apparatus: Filtering System Design



Experimental Set-Up: Test Cell and Backpulse System

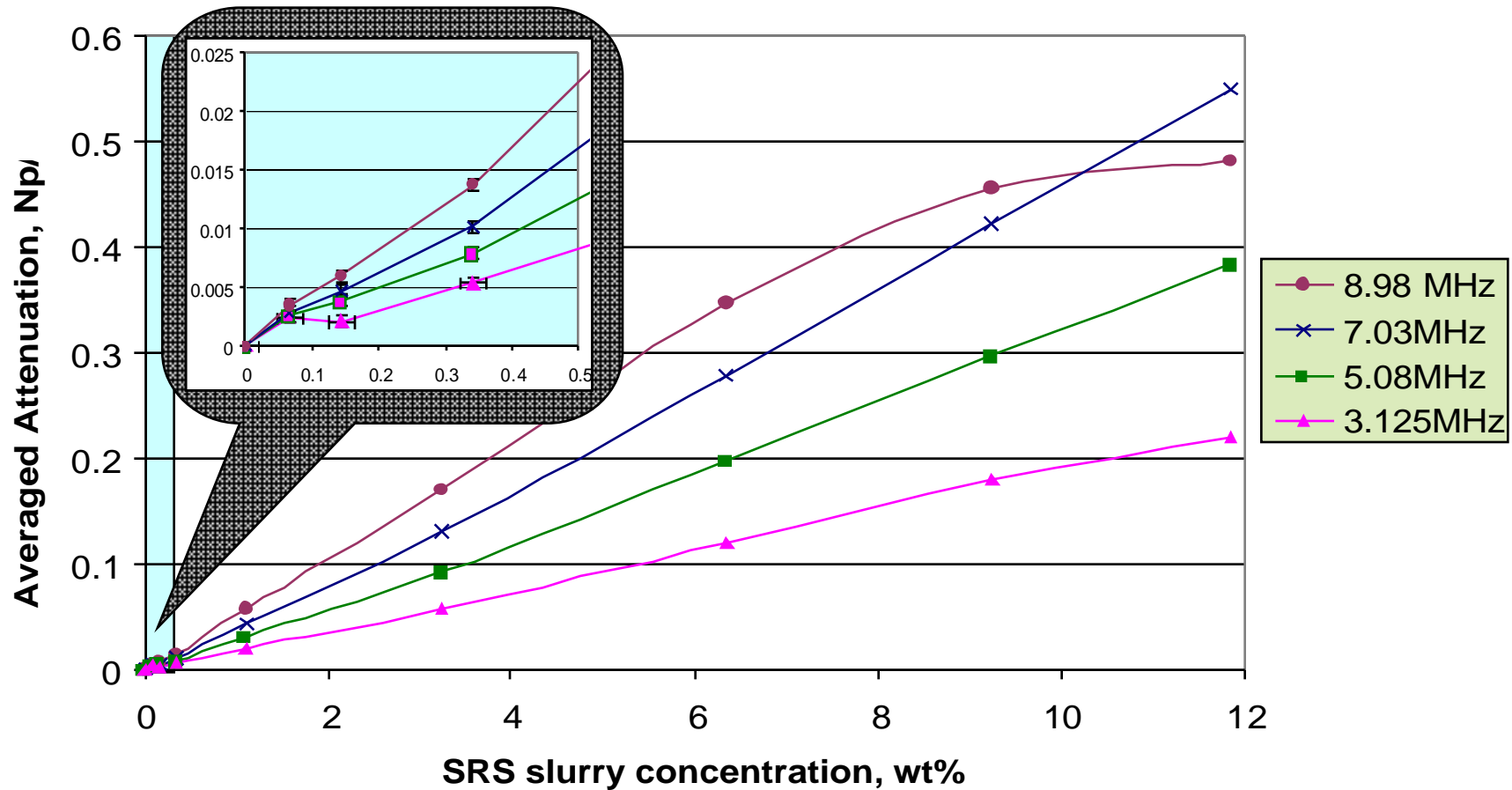


1. Flow Loop Test Cell
2. Reference Test Cell
3. Pump
4. Filter
5. High Pressure Backpulse Vessel
6. Computer-Controlled Valves
7. Flowmeters

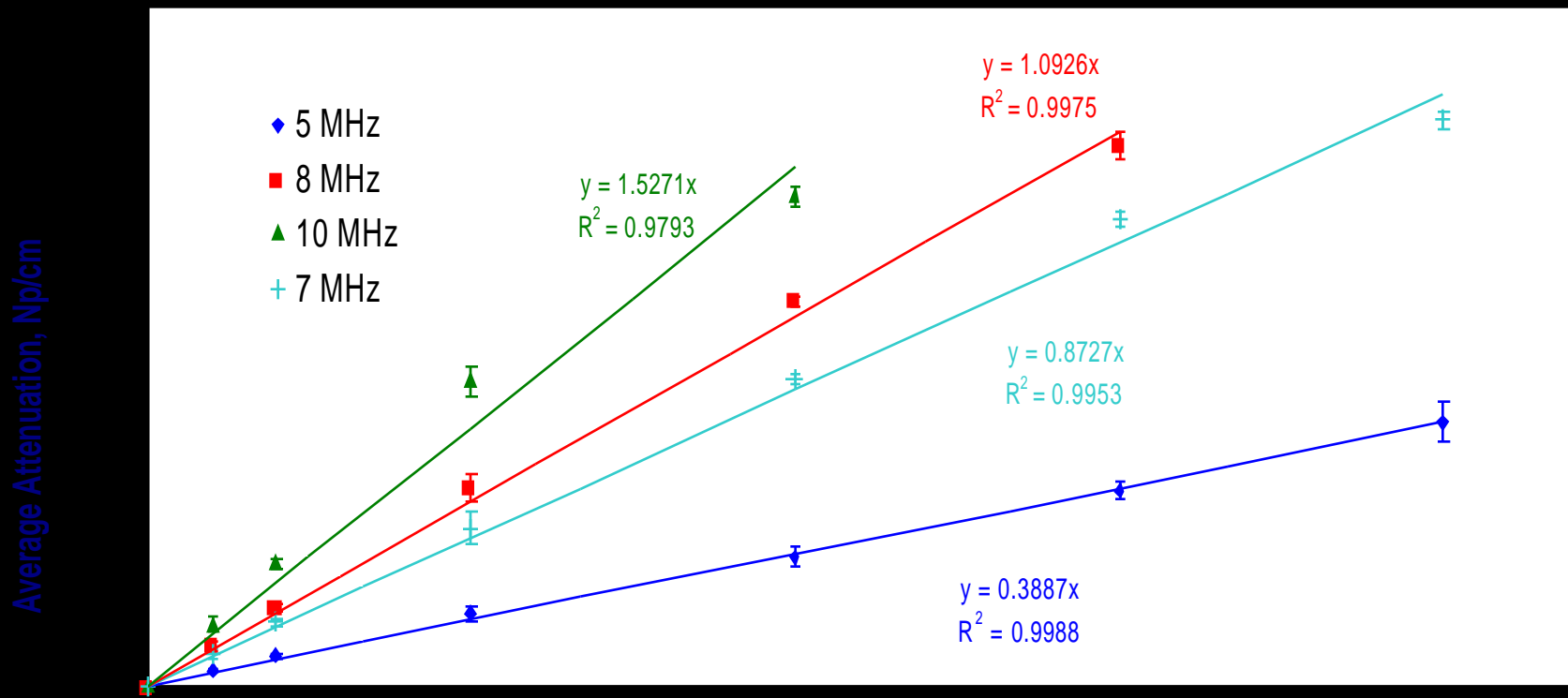


Calibration Experiments: SIMULANT SLUDGE TANK #8

Attenuation vs Concentration

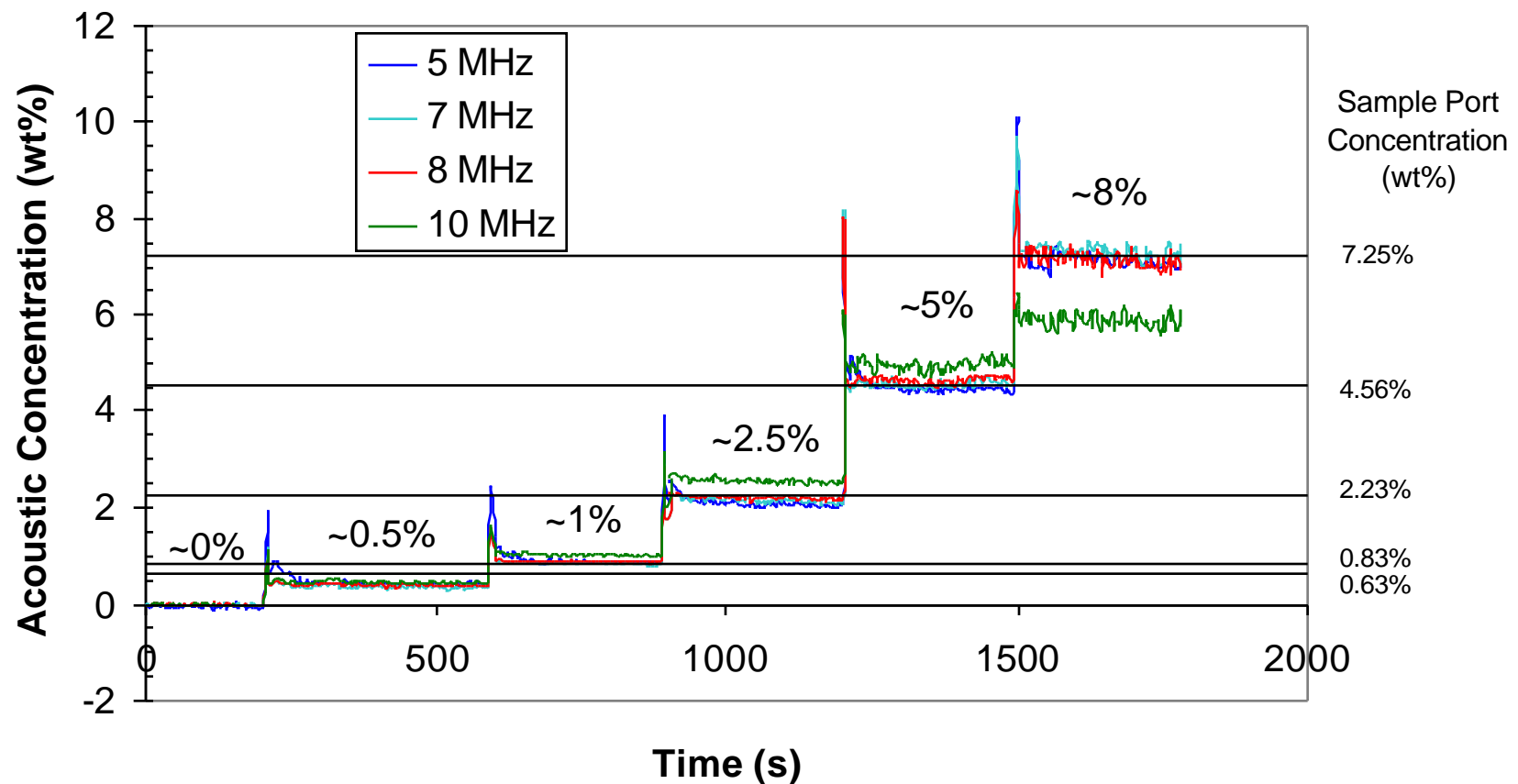


Calibration Experiments: G800

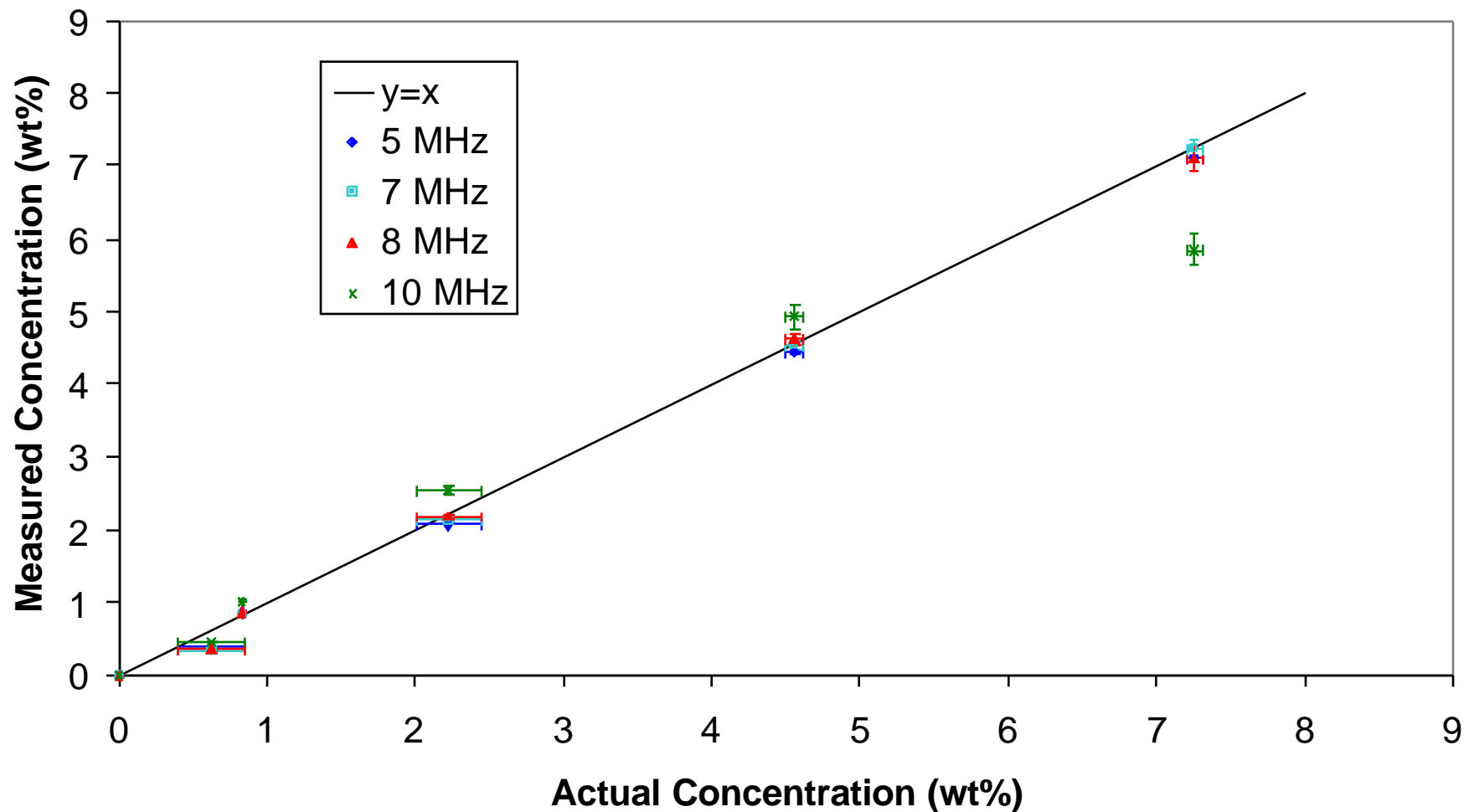


On-Line Concentration Measurements with Stepwise Solids Concentration Increases

Real Time Concentration Data

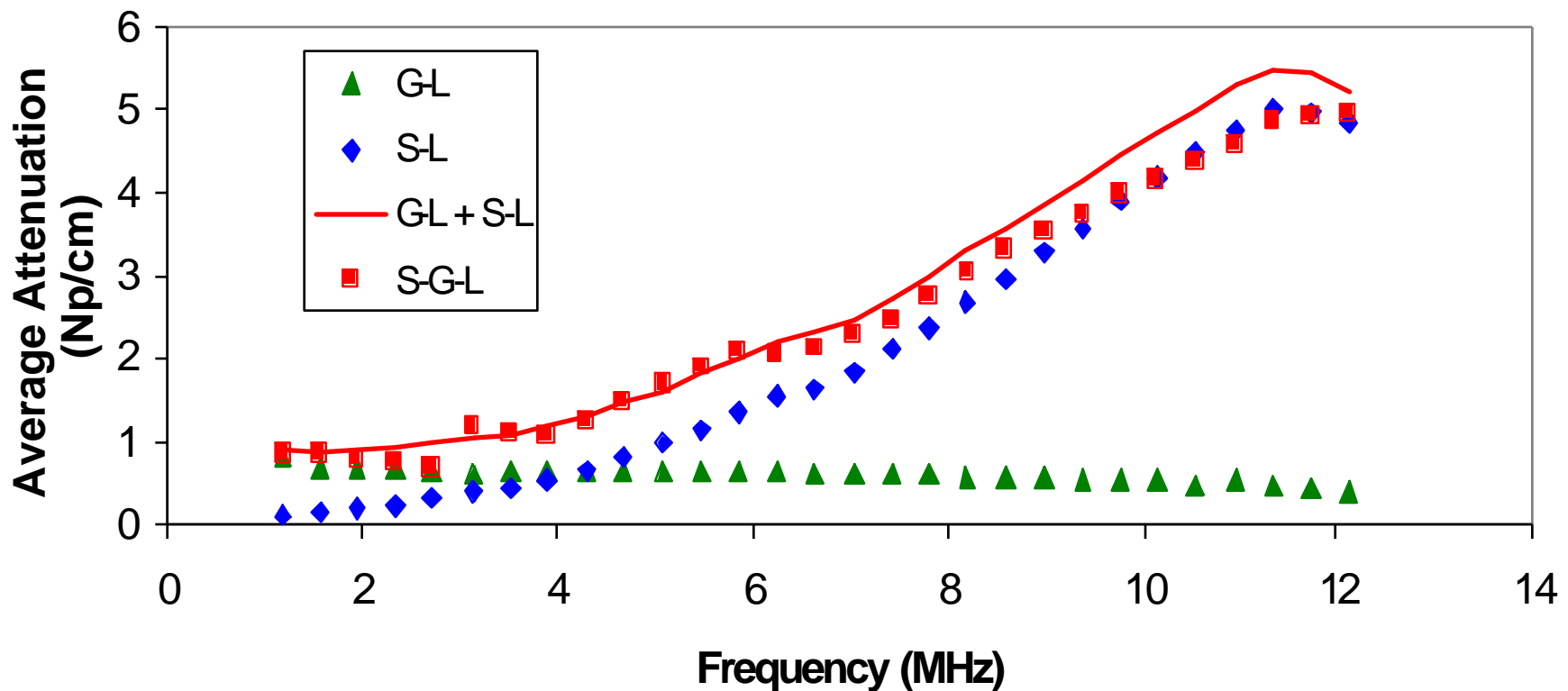


Comparison of the Acoustic Monitor and Direct Concentration Measurements from the Sampling Port (G-800)



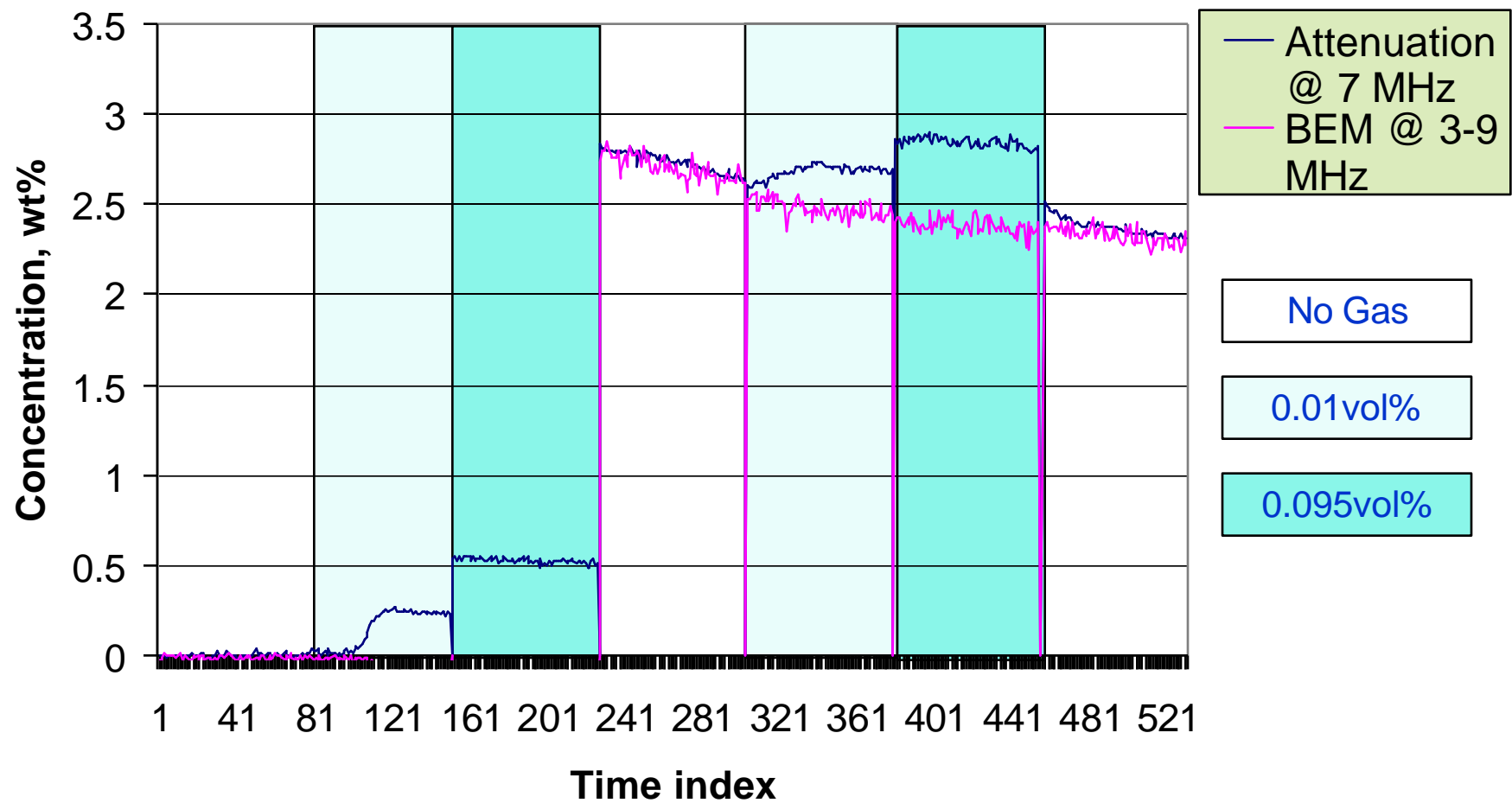
The Influence of the Gas Phase on the Attenuation of Ultrasonic Waves

2.5 wt% G-800 and 0.1 vol% air



Bubble Elimination Results

Measured concentration, G800



Conclusions

- 2.1. G-800 ceramic spheres and kaolin-bentonite (0.5—10wt%)
- 2.2. SRS simulant sludge, tank #8 (~0.05—12wt%)
- 3. Slurry flow loop permits performance evaluation of acoustic monitor for S-L, G-L, and S-G-L systems
- 4. Demonstrated on-line/real-time measurement of S-L concentrations (0.0—10.0 wt%)
- 5. Gas phase (0.005—0.1 vol%) attenuation interference can be removed to determine S-L attenuation in S-G-L mixtures

Future Work

3. Develop and demonstrate an acoustic probe for placement and measurement in mixing vessels
4. Expand applications to measure low gas concentration in gas-liquid and gas-liquid-solid systems

Bubbles motion



Solution

When the total volume fraction is small the above result can be extended to account for a non-uniform particle size distribution by integrating the attenuation caused by the particles over each size present:

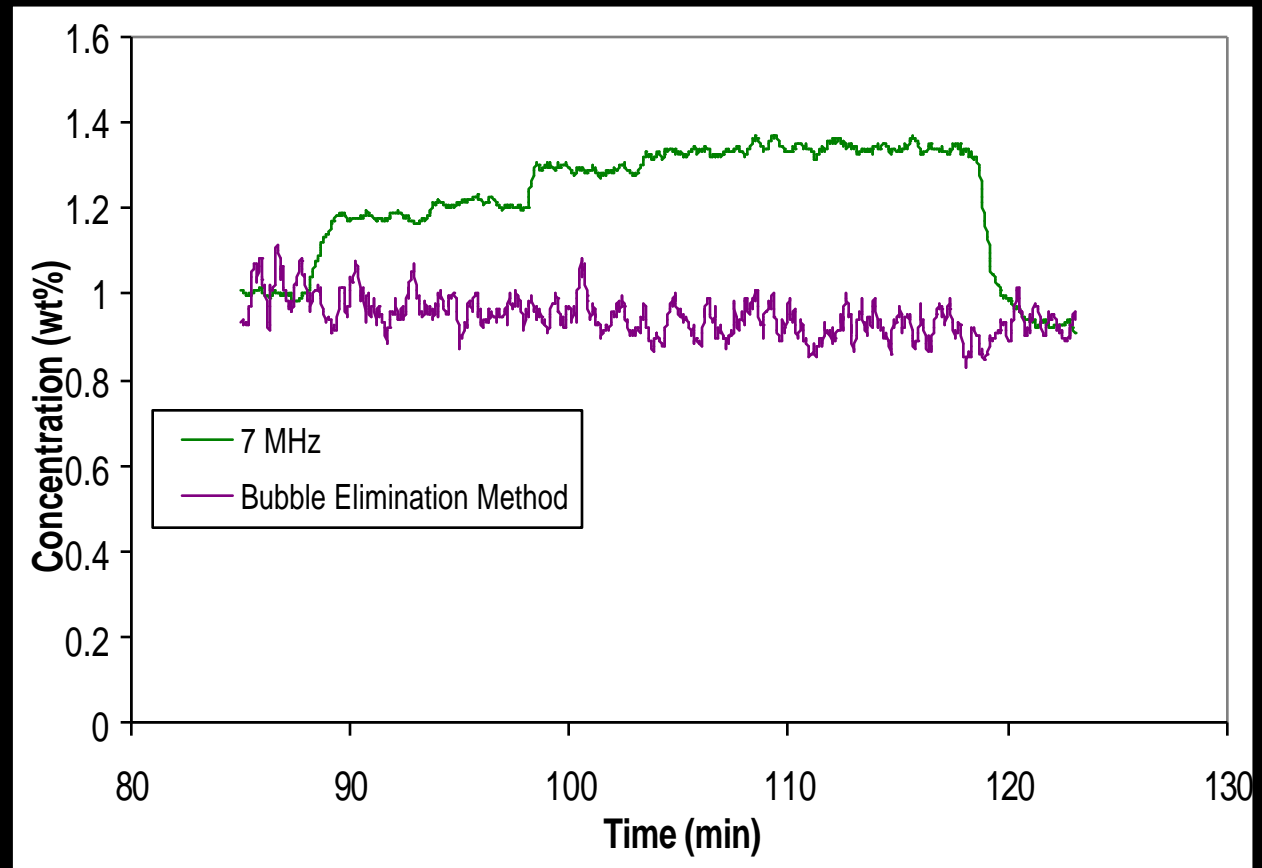
$$a_{tot}(f) = - \sum_0^{\infty} \hat{a}(f, a) f(a) da$$

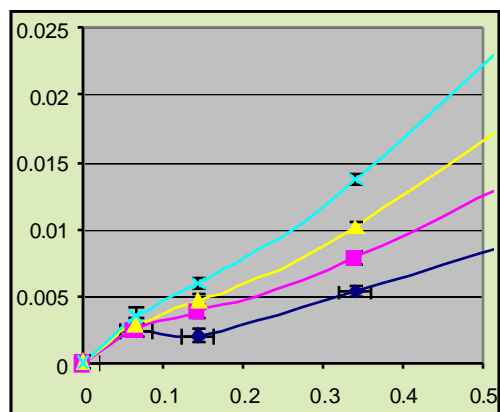
where

$\hat{a}(f, a)$ is the attenuation density and

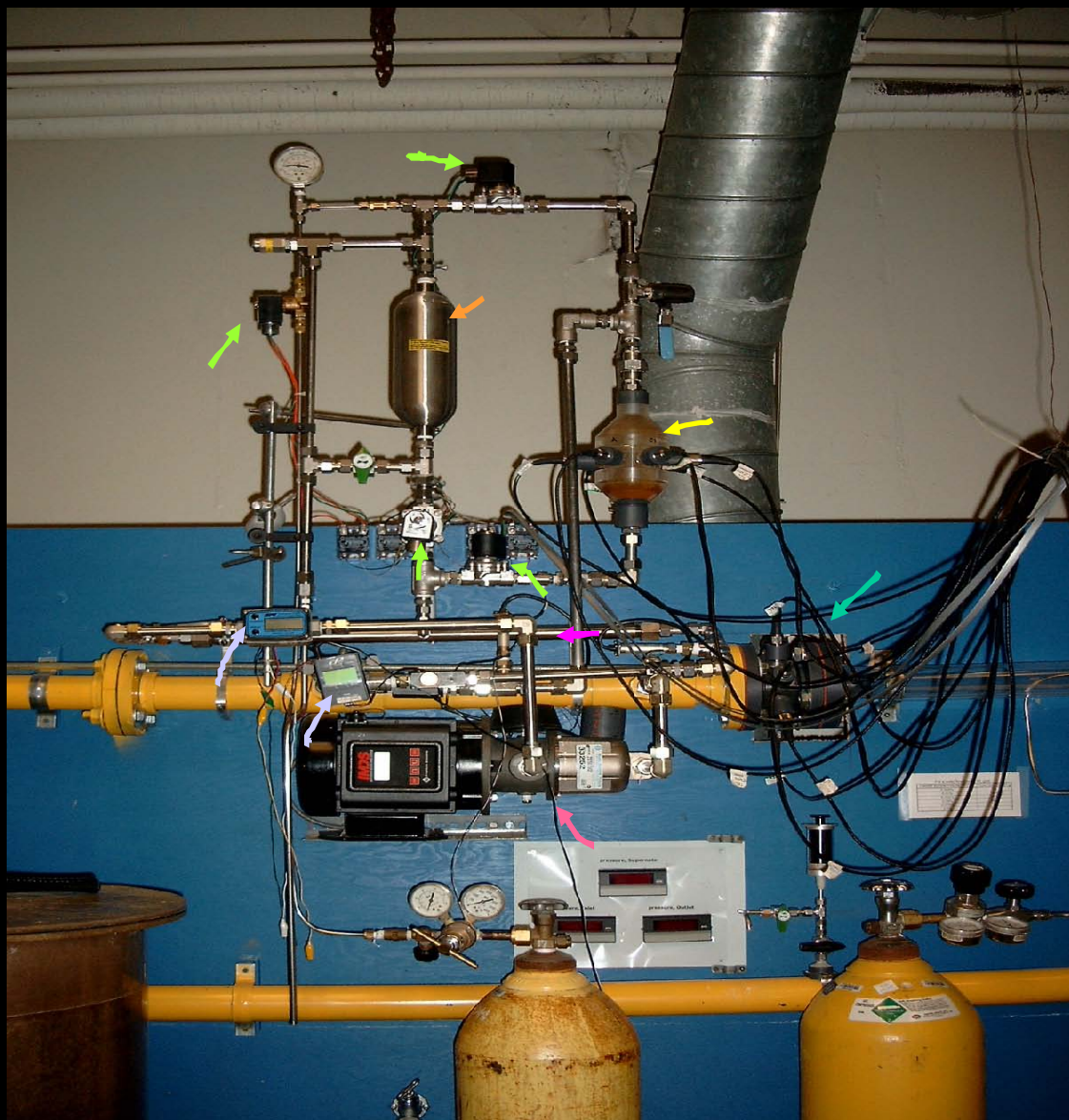
$f(a)da$ is the volume fraction of a particle size range between a and $a+da$

Bubble Elimination Results





Experimental Set-Up: Backpulse System



1. Flow Loop Test Cell
2. Reference Test Cell
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7. Flowmeters